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The interiorization of Brazilian violence, policing, and economic growth☆,☆

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Abstract

Brazilian homicide rates are among the highest in the world, inclusive of actual war zones. However, the character of Brazil's violence is changing. Recent analyses highlight a trend of dispersion of violence such that homicide rates in urban areas, traditionally the most violent places, have stagnated and declined while smaller cities and rural areas experienced a marked increase. An incipient explanation is that this trend is related to greater economic dynamism in the smaller cities, unaccompanied by increased policing. This article's empirical analysis uses locational Hoover indexes to express the dispersions of violence and economic activity, and also generates a proxy to measure the geographic concentration of police forces. Using panel data across all 26 states from 1995 to 2011, we find evidence of a correlation between dispersion of violence and GDP to less urban areas, and ambiguous results regarding police concentration.

JEL classification: K42; R58

Keywords: Homicides; Violence dissemination; Hoover index

Resumo

As taxas de homicídio do Brasil estão entre as mais altas do mundo, inclusive das atuais zonas de guerra. No entanto, o caráter dessa violência está mudando. Análises recentes destacam uma tendência de dispersão de violência, de forma que as taxas de homicídio em áreas urbanas, tradicionalmente os lugares mais violentos, estagnaram e declinaram, enquanto cidades menores e áreas rurais experimentaram um aumento acentuado. Uma explicação incipiente é que esta tendência está relacionada com um maior dinamismo econômico nas cidades menores, sem haver um aumento do efetivo policial. A análise empírica deste artigo utiliza índices locacionais de Hoover para expressar as dispersões da violência e da atividade econômica, e também um indicador para medir a concentração geográfica das forças policiais. Usando dados de um painel dos 26 estados brasileiros entre 1995-2011, encontram-se evidências de uma correlação entre a dispersão da violência e do PIB para as áreas menos urbanas, e alguns resultados ambíguos em relação à concentração da polícia

Palavras-chave: homicídios; disseminação da violência; índice de Hoover

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1. Introduction

Brazil is a violent place. In fact, the country ranks among the most violent nations in the world, with an intentional homicide annual rate ranging around 27 homicides per 100 thousand inhabitants. This rate is roughly two to three times that of the United States and upwards of 40 times that of Japan. To put Brazilian violence in perspective, consider some of these staggering facts[1]:

- Between 1980 and 2010 more people died in Brazilian homicides caused by fire arms than the combined total of the 12 bloodiest armed conflicts in the world during the same period.
- Brazil is one of the few countries in the world where homicide rates surpass traffic accident mortality rates.
- Nearly two in five of all registered deaths for men aged 15–24 are the result of homicides.

These levels of violence exist and persevere despite Brazil being a nation without territorial disputes, civil war, or pronounced racial or ethnic tensions. It is clear that this violence costs Brazilian society dearly and is therefore among the nation's top challenges.

However, the nature of this violence is changing. Waiselfisz (2011), in his annual editions of *Mapa da Violência*[2] (Map of Violence), noted that in recent years big cities experienced declining rates of violence while the previously tranquil countryside saw dramatic increases. He termed this shift the *interiorization* of violence. Andrade and Diniz (2013) analyzed Waiselfisz's data and found indications that the areas that experienced the greatest uptick in violence also had the greatest economic growth.

The standard analysis of the economics of crime is based on Becker (1968), and assumes criminals act rationally considering not only the benefits, but also the costs of their actions. If the probability of being caught is low, then the expected benefits of committing a crime may outweigh the costs. In this light, criminal activity, and therefore violence, should increase in lockstep with economic growth (increased benefits) and a lacking police presence (reduced costs).

Following the rationale of Becker, the conclusions of Andrade and Diniz (2013) appear to explain only part of the interiorization of violence – that violent criminals are drawn to the benefits associated with economic dynamism. However, the migration of violence to the countryside could also be framed in terms of costs. Specifically, criminals are likely incentivized to migrate to the countryside to take advantage of the reduced costs associated with a lacking police presence. For example, Di Tella et al. (2004), Evans and Owens (2007) and Draca et al. (2011) already documented causal relationships between greater policing and less crime.

In fact, the press has also taken notice of criminals targeting less well-policed areas. News stories abound, highlighting trends of crime, and especially violent crime, migrating from big cities to rural areas. The media reports these stories on a frequent basis and emphasize the lacking police presence in the countryside vis-a-vis urban centers as causal to the migration.[3]

Brazil attempted to combat its violence epidemic by raising the costs violent criminals faced by increasing spending on public security. According to the Anuário Brasileiro de Segurança Pública (ABSP, Annual Yearbook of Public Safety)[4] and the Secretaria do Tesouro Nacional (STN, Secretary of the Treasury)[5] the total expenditures in public security among states more than doubled from 1995 to 2011 from R$ 109 to R$ 252 per person. Additionally, the policed force nearly doubled from roughly 306 thousand state police in 2004 (the first year of ABSP) to 527 thousand by 2011. In relative terms, this was a rate increase of 171 police per 100 thousand inhabitants to 290.

If these expenditures were more heavily concentrated in urban areas, which would leave the countryside relatively less secure, it may explain the spread of violence to these less populated areas. It is this possibility, which suggests that violent criminals are fleeing the more heavily-policed urban areas for less well-protected targets in the countryside, that

[1] Details in UNODC (2011).

[2] See mapadaviolencia.org.br.

[3] One compelling anecdote suggesting the interiorization of violence highlights a criminal gang in Goiás that specializes in armed robbery of ATM cash machines. In a taped conversation, gang leaders consider potential targets based on their relative lack of security resources. In this example, the gang preferred to rob ATMs in a smaller city with "only two police officers and one patrol car." See 1:05 the video: g1.globo.com/bom-dia-brasil/videos/t/edicoes/v/presa-quadrilha-que-explodia-caixas-eletronicos-em-goias/2934315

[4] See forumseguranca.org.br/produtos/anuario-brasileiro-de-seguranca-publica.

[5] See: tesouro.fazenda.gov.br/estados_municipios.

is often presented in the media. However, to explore the viability of this assertion requires knowledge of the distribution of the police force within states.

Unfortunately, data on the geographical distribution of the police force is not readily available. ABSP, which gathers aggregate data from the Labor Ministry's (Ministério do Trabalho) Relação Anual de Informações Sociais (RAIS, Annual Report on Social Information),[6] only calculates the total number of police in the state. It is not able to break out the distribution of the police force by municipality because the civil and military police forces, as state entities, registers its officers in the state capital rather than the cities in which they actually work. Therefore, little can be said on how the police force is distributed within a state.[7]

To address this limitation, we develop a proxy capable of capturing the geographical distribution of the police force. This proxy is developed by obtaining household and census data from the Instituto Brasileiro de Geografia e Estatistica (IBGE) and then comparing it to respondents that identify as military police from the Classification of Brazilian Occupations (CBO).[8]

Armed with a method to determine the geographical distribution of the police force within a state the article takes aim at analyzing the trend of interiorization of violence. First, we propose a measure to capture the trend of violence dispersing from population centers to the countryside, known as the locational Hoover index. As will be seen, this metric, which is flexible to each location or municipality considered, is more capable in measuring interiorization when compared to the simple binary approach of categorizing municipalities into two categories – either countryside or urban. Additionally, the index has straight-forward interpretation as is interpreted as the percent of homicides that would need to be redistributed across all municipalities for a state to achieve an equal homicide distribution.

Having a way to more adequately measure the dispersion of violence, this research evaluates how key variables are related to the trend of interiorization. First, as in Andrade and Diniz (2013), our model focuses on the incentives or benefits violent criminals may have to migrate to more rural locations by considering each state's relative concentration of GDP. States that have increased economic activity in the countryside may attract crime to these areas of new-found prosperity. Secondly, as evidenced in the media, our model includes the geographical concentration of the police force to determine the extent to which an increased police presence in urban areas is related to the dispersion of violence. Ultimately, we find evidence of a correlation between dispersion of violence and increased economic dynamism in less urban areas, but ambiguous results regarding the relationship between interiorization and the concentration of the police force in urban areas.

The balance of this paper is organized as follows. Section two explains the motivation and context that underpin this research. Section three explains the methodology and data by focusing on the development of the locational Hoover index, our proxy for police force concentration, and the empirical model. Section four discusses key results. Conclusions are offered in the final section.

2. Motivation and context

While considering the background and motivation for studying patterns of violence in Brazil, it is necessary to justify our choice to use the homicide rate as the best overall indicator of violence. Although violence manifests itself in various forms ranging from intimidation to robbery to murder, this study follows Waiselfisz (2011) in considering homicidal violence as the best measure of violence. The first reason that the homicide rate is the most adequate measure of violence is that murder reveals violence in its most severe form. In this sense, relating violence to homicides is akin to public health studies that measure the effect of an endemic by its death toll. The second reason homicides are the best measure of violence is one of practicality – there are simply few alternatives. Trustworthy and comprehensive data on lesser forms of violence, such as armed robbery, are serially under-reported, misreported, miscategorized, and prone to heterogeneity across micro-regions. Police precincts lack uniformity in defining and categorizing violent acts, and may feel pressure to underreport crime and violence statistics. An advantage to using homicides is that they less

[6] See: mte.gov.br/rais.

[7] As highlighted in the survey of Santos and Kassouf (2008) about criminal studies in Brazil, the national data bases are extremely limited.

[8] See: mtecbo.gov.br. IBGE, Brazilian Institute of Geography and Statistics. CBO, Classificação Brasileira de Ocupações. Data on households are determined from PNAD (Pesquisa Nacional por Amostra de Domicilio) the National Research of Household Samples.

Table 1
Homicide rate rankings for Brazilian States, 2000 and 2010.

	2000		2010	
State	Rate	Position	Rate	Position
Alagoas	25.6	11th	66.8	1th
Espírito Santo	46.8	3th	50.1	2th
Pará	13.0	21th	45.9	3th
Pernambuco	54.0	1th	38.8	4th
Amapá	32.5	9th	38.7	5th
Paraíba	15.1	20th	38.6	6th
Bahia	9.4	23th	37.7	7th
Rondônia	33.8	8th	34.6	8th
Paraná	18.5	16th	34.4	9th
Distrito Federal	37.5	7th	34.2	10th
Sergipe	23.3	12th	33.3	11th
Mato Grosso	39.8	5th	31.7	12th
Amazonas	19.8	14th	30.6	13th
Ceará	16.5	17th	29.7	14th
Goiás	20.2	13th	29.4	15th
Roraima	39.5	6th	27.3	16th
Rio de Janeiro	51.0	2th	26.2	17th
Mato Grosso do Sul	31.0	10th	25.8	18th
Rio Grande do Norte	9.0	24th	22.9	19th
Tocantins	15.5	19th	22.5	20th
Maranhão	6.1	27th	22.5	21th
Acre	19.4	15th	19.6	22th
Rio Grande do Sul	16.3	18th	19.3	23th
Minas Gerais	11.5	22th	18.1	24th
São Paulo	42.2	4th	13.9	25th
Piauí	8.2	25th	13.7	26th
Santa Catarina	7.9	26th	12.9	27th

Data Source: Mapa da Violência. Table generated by authors.

prone to interpretation and manipulation. Homicides must be officially registered on death certificates, typically by trained medical professionals, and are therefore more likely to be credibly and consistently reported.

Beyond acknowledging Brazil's severe violence epidemic, it is also critical to recognize that the character of violence is changing. Places such as Rio de Janeiro and São Paulo – once undisputed leaders in the Brazilian violence panorama – realized a dramatic reduction in their homicide rates. During the same time period less populated and previously peaceful regions experienced increased levels of violence. Waiselfisz (2011) separates these dynamics of violence dispersion from populated to rural areas into two components: *dissemination* and *interiorization*. Dissemination accounts for the part of the migration that occurs when violent crime leaves one state for another. This phenomenon can be thought of as migration *between* states. Table 1 highlights how the seven most violent states in 2000 became much *less* violent by 2010. During the same period however, the 17 least violent states in 2000 became much *more* so. The outcomes are striking.

During this 10-year span, the most violent states, with the exception of Espirito Santo, became much *less* so. In fact, in the seven most-violent Brazilian states, homicide rates fell from 47.1 to 22.6. The most dramatic changes occurred in São Paulo and Rio de Janeiro whose rankings moved from 4th to 25th and 2nd to 17th place, respectively. The counter examples showing relatively peaceful states turn to violence are equally striking. The 17 safest states saw homicide rates more than double from 11.7 to 28.4. Previously safe states, such as Alagoas and Pará, changed the most dramatically. Pará moved from 21st to fourth place and Alagoas moved from 11th place to become the most violent state in Brazil.

This research focuses on the second component of the violence dispersion referred to as *interiorization*. This phenomenon is characterized as intra-state redistribution and is typically explained by violence leaving capital cities and larger metropolitan areas for the countryside.

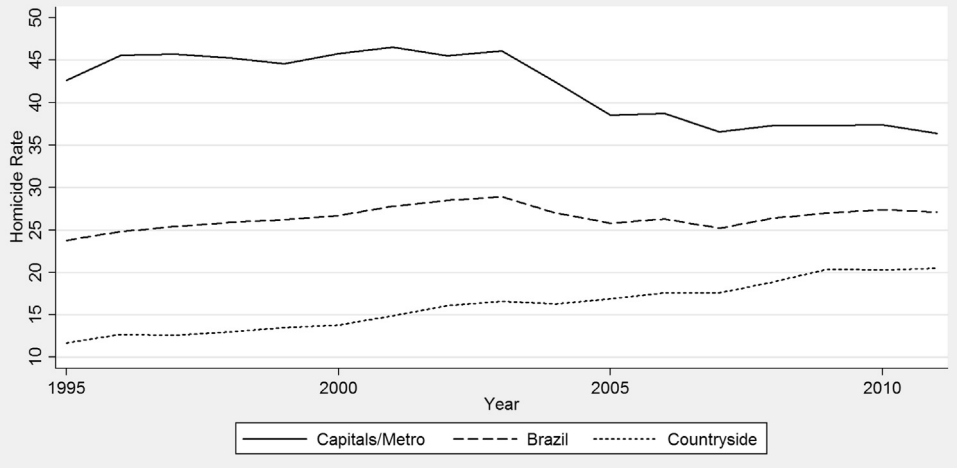


Fig. 1. Homicide rates in the Capital and Metropolitan Regions, Brazil and Countryside. Source of data: SIM/SVS/MS.

Fig. 1 shows the evolution of homicide rates from 1995 to 2011 in the capital/metropolitan regions, at the national level, and the countryside using data from the Brazilian Health Ministry's information department, *Sistema de Informações sobre Mortalidade* and *Secretaria de Vigilância em Saúde* (SIM/SVS/MS).[9]

Of note is the declining trend in the homicide rate in capital cities and larger metropolises after 2004. This declining tendency could be attributed to the Estatuto do Desarmamento (Disarmament Statute) which came into effect in the same year and greatly restricted the civilian population's access to weapons. The effects of Estatuto do Desarmamento on violence are covered more extensively by Dreyfus and Nascimento (2005), Soares and Scorzafave (2008) and Cerqueira and Mello (2012), and, we do not elaborate on the specifics in this article. However, Fig. 1 also shows an increasing trend of violence in the countryside throughout the period that is consistent with Waiselfisz's pattern of interiorization.

Following Becker (1968), one possible explanation for the rise of homicides in the countryside, is that a criminal's incentives, or expected benefits, to conduct violent behavior may have changed relative to urban areas. Andrade and Diniz (2013) argue that this violence increase is related to the higher expected benefits associated with greater economic growth in the smaller cities and towns. Their spatial analysis, which is more sophisticated than Waiselfisz's simple break out of urban and rural areas, suggests that interiorization did not happen evenly across all municipalities. Specifically, they find that violence tended to cluster around areas with increased economic dynamism where land use was recently reorganized, suggesting that violence may be *following the money* to rural areas with new found wealth. Andrade and Diniz (2013), however, did not conduct a formal statistical analysis to confirm their hypothesis. This research fills this void by empirically modeling the relationship between the dispersion of violence and relative changes of economic prosperity within states.

We also consider the expected costs associated with conducting violence. News stories abound suggesting that violent crime migrated from urban to rural areas due to the precarious police presence found in the countryside. Newspapers and social media are replete with examples that suggest these violent crimes occurred, at least in part, due to inadequate policing. The low probability of being apprehended or injured while perpetrating these crimes likely lowers a criminal's perceived costs. Stories and reports that highlight the difficulties encountered by the police in small town Brazil vary in scope. Some anecdotes tell the story of policemen, critically short on backup support, that are unwilling to confront heavily armed bandits to stop a crime.[10] Other reports highlight the difficulty of keeping the peace in communities that have only one police officer.[11] Others assert that bandits are taking to the highways to prey on smaller, less protected areas, outside of the urban core.[12] These examples suggest that inadequate police forces

[9] See Santos and Kassouf (2008) for details about SIM/SVS/MS databases.
[10] https://youtube/5BCxqhRGvoE.
[11] http://zh.clicrbs.com.br/rs/noticias/noticia/2015/05/cidades-do-interior-tem-apenas%-um-policial-militar-4762170.html.
[12] http://diariodonordeste.verdesmares.com.br/cadernos/policia/crime-migra-para-o-interior-1.659806.

fail to prevent crime from happening. Yet another downside of inadequately manned precincts is that they don't have sufficient resources to investigate, prosecute, or punish criminals known to have perpetrated heinous acts.[13]

The hypothesis of greater economic dynamism in the smaller cities introduced by Andrade and Diniz (2013), together with news stories and anecdotes presented in the Brazilian media, are consistent with Becker (1968) in that criminals are motivated by profit and will seek to minimize their costs and maximize their rewards. This argument is also consistent with Di Tella et al. (2004) that found a large deterrent effect of observable police on crime. In this sense, a logical outcome of increased public expenditures on law enforcement in cities may be to push criminals toward less-policed areas, since it raises their costs. Likewise, violence moving to areas of recent economic development is also consistent with Becker's theory of profit maximizing criminals.

But deterring crime by raising criminal's expected costs is almost certainly an incomplete analysis. The traditional public security model, which focuses on controlling criminal behavior through policies that focus on the consequences of being caught committing a crime, fails to consider the underlying root causes of violence. While raising the costs of committing crime may deter crime up to a point, to truly diminish violence, rather than merely shift its location, a comprehensive approach is required.[14]

Similarly, it is prudent to consider other social indicators that influence violence. One of the most common topics in the general literature of violence explores the relationship between income inequality and violence. The works of Marmot et al. (1987) and Towsend and Davidson (1990) generally show that unequal income distributions are related with higher homicide rates. These relationships also hold for Brazil. As demonstrated by Szwarcwald et al. (1999), homicide rates, as well as several indicators of health, are highly correlated with income inequality within the state of Rio de Janeiro. In Brazil a robust literature, that includes a survey of Santos and Kassouf (2008), aims to explore the diverse causes that generate violence within its borders. Lima et al. (2005), discusses several of the socioeconomic determinants that contribute to the high rates of homicides in the state of Pernambuco. This research creates a spatial analysis using a host of factors such as precarious living situations, exposure to crime and drug trafficking, unemployment, illiteracy, income, and a lack of upward mobility. Income inequality is viewed as a particularly important factor that fuels an individual's frustration and prevents them from achieving "socially legitimate goals". Violence is also shown to affect the population in unequal ways and is skewed toward certain demographics – particularly young, male, black individuals that reside in certain geographic areas. Urbanization is also associated with heightened levels of violence.

The complex nature of violence demands that to explain the dispersion of violence, one must consider more possible factors beyond than the economic approach espoused by Becker (1968). Researchers are compelled to analyze the roots and causes of violence through alternative lenses of public health, psychology, biology, and political science, and economics. This multidisciplinary approach allows for an analysis from varied angles and results are often complementary with economics-based studies. When considering Brazil's violence panorama, one must remember the myriad factors that shape violent outcomes, in addition to economic growth and the distribution of security forces.

3. Methodology and data

This section is divided in five parts. The first argues that the dichotomy of interior/capital presented in Waiselfisz (2011) may not be adequate to measure "interiorization", and presents the **locational Hoover** as a superior metric. The second section highlights that Hoover statistics calculated for homicides (homicide Hoovers) are correlated with Hoover statistics calculated on GDP (GDP Hoovers). This correlation supports Andrade and Diniz (2013) by showing that violence spreads to the countryside along side economic prosperity. The third section presents the relationship between homicide Hoovers and expenditures on security and suggest that, in line with the media's assertion, violence may be attracted to areas with less security. The fourth section proposes a proxy to measure the geographical concentration of the police force. The fifth section discusses the econometric model.

[13] http://mais.uol.com.br/view/8bak1uywu0n2/crimes-ficam-impunes-por-falta-de-estrutura-da%%-policia-civil-em-caruaru-04028C1B3364D09-95326?types=A.

[14] See, for example, Assis (1999) or Cruz Neto and Moreira (1999).

Table 2
Numerical example.

	Order 1			Order 2		
i	p_i	h_i	v_i	p_i	h_i	v_i
1	.4	.7	−.3	.4	.7	−.3
2	.3	.1	.2	.1	.1	0
3	.2	.1	.1	.2	.1	.1
4	.1	.1	0	.3	.1	.2

3.1. Locational Hoover overview

The analyses of Waiselfisz (2011) and Andrade and Diniz (2013) aimed to highlight the contrast between the character of violence found in urban and rural areas, in order to quantify its dispersion. Their analyses have the advantages of being intuitive and relatively easy to construct, but they are unable to consider economically thriving smaller cities to where violence can also spread. In order to better quantify this dispersion, we propose the **locational Hoover** index.

The **locational Hoover** index is a measure typically employed by geographers, as noted in Hoover (1941) and Rogerson and Plane (2013), used to analyze population concentrations relative to land areas. In Zhao et al. (2003) Hoover is also called a **Spatial Imbalance Index**. While the Hoover index could be applied to measure inequality, such as income inequality, we specify a locational Hoover to underscore its application in measuring spatial imbalance. This locational Hoover index's construction allows it to measure the relative concentration or imbalance between any two entities and is specified:

$$Hoover_t = \frac{1}{2}\sum_i \left| \frac{P_{it}}{\sum_i P_{it}} - \frac{H_{it}}{\sum_i H_{it}} \right|$$

where $Hoover_t$ is the statistic in year t, and P_{it} and H_{it} are population and number of homicides of the given municipality i at year t, respectively.

Thus, the Hoover index relates any given municipality's proportion of the overall population to its relative proportion of homicides. The statistic is bounded between 0 and 1, such that lower values indicate more balanced distributions while values approaching unity are more imbalanced.

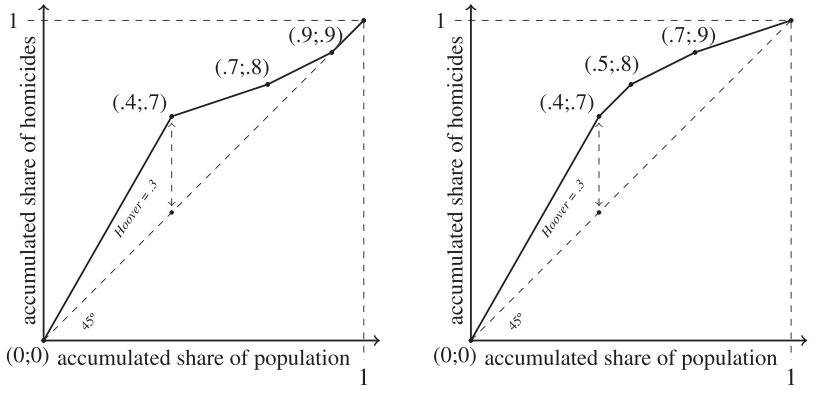
One of the homicide Hoover's advantages is its straightforward numerical interpretation. The statistic itself is interpreted as the percentage of the total homicides that would need to be redistributed across all municipalities for a state to achieve an equal homicide distribution.

Table 2 offers a example that outlines the usefulness of Hoover in measuring the distribution of violence. First, consider a space containing $i = 1, \ldots, n$ units of observation and a measure of relative violence, v_i, where $v_i = p_i - h_i$, $p_i = (\Sigma_i P_i)^{-1} P_i$ and $h_i = (\Sigma_i H_i)^{-1} H_i$. v_i represents the relative imbalance of violence of unit i with respect to all units of observation.

In **Order 1** the most violent region in the set is $i = 1$ which possesses 70% of the total homicides and has 40% of the total population. Its $v_i = -.3$, is the largest in magnitude in the sample and the fact that its value is less than zero implies that region $i = 1$ is more violent relative to the average. Correspondingly, observations with $v_i > 0$, such as $i = 2, 3$ show regions relatively less violent in comparison to the set as a whole. The final observation, $i = 4$, with a $v_i = 0$ is an example of a region where levels of violence are exactly proportional to its population.

These proportional differences of homicides relative to population, v_i, are in turn used to construct the Hoover Index, $.5\Sigma_i|v_i|$, for the entire set of observations. The Hoover statistic in this example is.3, which has the interpretation that 30% of the homicides must be spatially reallocated to ensure a balanced distribution of violence.

To highlight Hoover's suitability when compared to other measures consider the following. In cases where there exists only one possible ordering of the variable of interest, the ordering is considered single dimension. This is the case, for example, when measuring income inequality. However, in cases where there exist multiple variables of interest, or multidimensional, the order matters. In the multidimensional case it is necessary to specify **locational** to make the distinction.



(a) Order 1 (b) Order 2

Fig. 2. Locational Lorenz curve: graphical analysis by order.

To see why order matters, consider **Order 1** from Table 2. In Order 1, the regions are ranked, from highest to lowest, in terms of homicides. In Order 2 they are ranked according to population. Although the two regions considered are identical, the dimension by which they are ordered, can lead to inconsistent outcomes when calculating a Gini Index.

To demonstrate this contradiction consider the Lorenz curve in Fig. 2a. The Gini coefficient is represented by the area between the 45 degree line and the Lorenz curve divided by.5, and is calculated by summing the area of 4 trapezoids and subtracting the triangle. In this case the Gini statistic is calculated as:

$$Gini = \begin{pmatrix} (.7+0) & (.4-0) & + \\ (.8+.7) & (.7-.4) & + \\ (.9+.8) & (.8-.7) & + \\ (1+.9) & (1-.8) & \end{pmatrix} - 1 = .28$$

When ranked by population, as in Order 1, it is calculated as.28.

Now consider **Order 2** from Table 2, where regions are ranked according to homicides. In this case the Gini statistic is calculated as:

$$Gini = \begin{pmatrix} (.7+0) & (.4-0) & + \\ (.8+.7) & (.5-.4) & + \\ (.9+.8) & (.7-.5) & + \\ (1+.9) & (1-.7) & \end{pmatrix} - 1 = .34$$

Despite being identical samples, the dimension by which they are ranked, can lead to different Gini statistics.

Additionally, there are two other orderings possible: ranking homicides smallest to largest with population smallest to largest as well as homicides smallest to largest with population largest to smallest. This would move the position of the curve either above or below the 45 degree line.

However, unlike the Gini, the Hoover index is invariant to the dimension by which the data set is ordered. As demonstrated by Alonso-Villar (2011), the Hoover index is always the greatest distance between the line of equality/equal distribution and the Lorenz curve. As seen in Fig. 2, the Hoover does not change if the Lorenz curve is above or below the 45 degree line.

The Hoover index is particularly apt to analyze patterns across time to identify trends in dispersion or concentration. If, for example, $\Delta Hoover < 0$, between two consecutive periods, violence is spreading more equally across the regions. Likewise a $\Delta Hoover > 0$ between periods indicates that violence has become more concentrated.

Armed with information on homicides and populations, the Hoover index can be applied to measure and detect shifts in the distribution of violence. The homicide rate, expressed as the number of homicides per 100 thousand inhabitants,

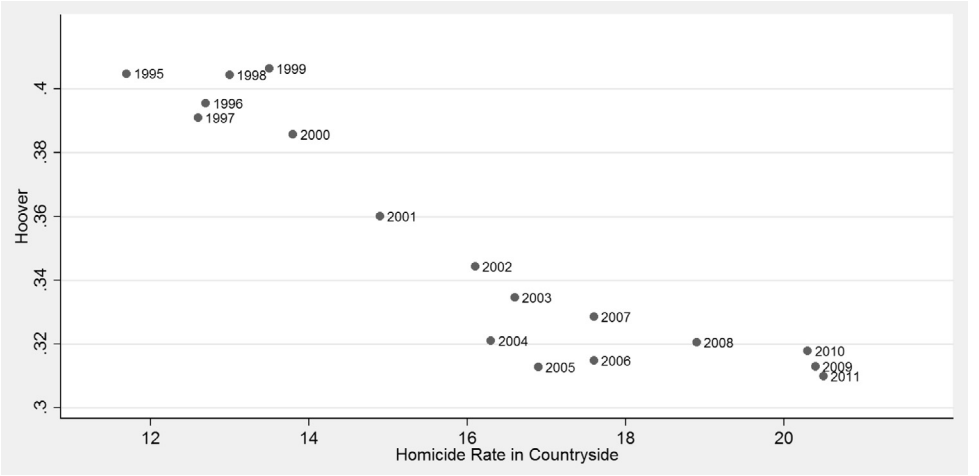


Fig. 3. Scatter between Homicide Rate in Countryside and Hoover Index (calculated for all municipalities in Brazil). Source of data: SIM/SVS/MS.

is an effective way to measure the relative level of violence within a specific observation such as a municipality. The homicide Hoover index, however, allows for interpretation beyond a single observation/location to characterize the relative distribution of violence across numerous observations within a data set.

Fig. 3 uses data on homicides to show how the Hoover homicide index characterizes the interiorization of violence raised by Waiselfisz (2011). The scatter between homicide Hoover in the countryside and the national homicide Hoover, which considers all Brazilian municipalities, emphasizes how Hoover is able to illustrate the phenomenon of interiorization. For example, the 1990s are marked by relatively high national Hoovers and relatively low countryside Hoovers suggesting that the distribution of homicides was less equally distributed at the national level when compared to rural areas. The trend toward interiorization is evident throughout the 2000s which showed a more equal national distribution of homicides and a less evenly distributed homicides in rural areas. These patterns suggest that while the national distribution of homicides became more equal across time, certain unfortunate rural municipalities bore the brunt of increases in violence.

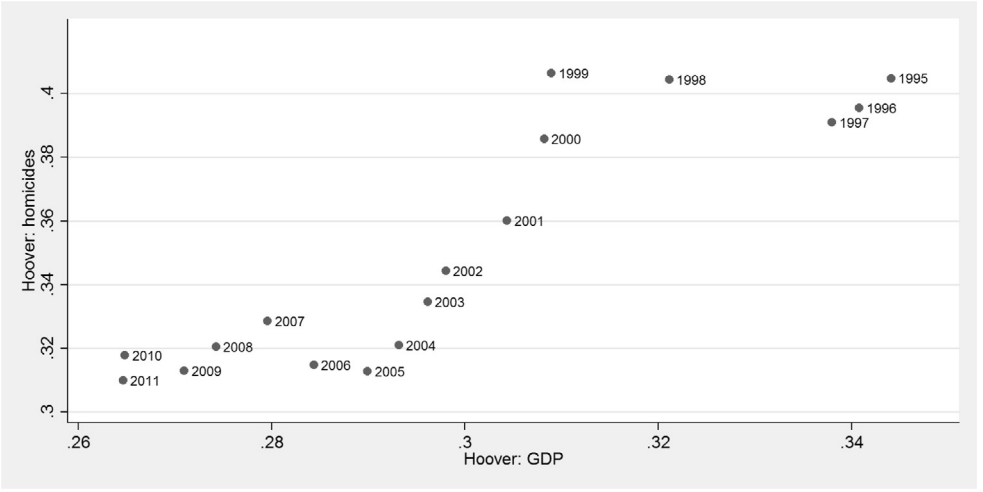
Overall, there are numerous advantages in using the Hoover to index to analyze distributions. The locational Hoover index:

1. is a more comprehensive measure when compared to the dichotomy of urban/rural, and thus represents an improvement over the measures used in Waiselfisz (2011) and Andrade and Diniz (2013);
2. captures the interiorization phenomenon in a single variable, obviating the need to make side-by-side comparisons between two variables, and facilitating regression analysis;
3. is easy to calculate allowing it to be applied to similar studies;
4. has a straightforward interpretation that measures the **imbalance** of a dataset;
5. is invariant to the ordering of multivariable data sets, which is different than the locational Gini; and,
6. does not require the calculation of a log, as with the Theil index. This advantage is particularly relevant in data sets that include many zeros, as is the case when a large number of municipalities register zero homicides.

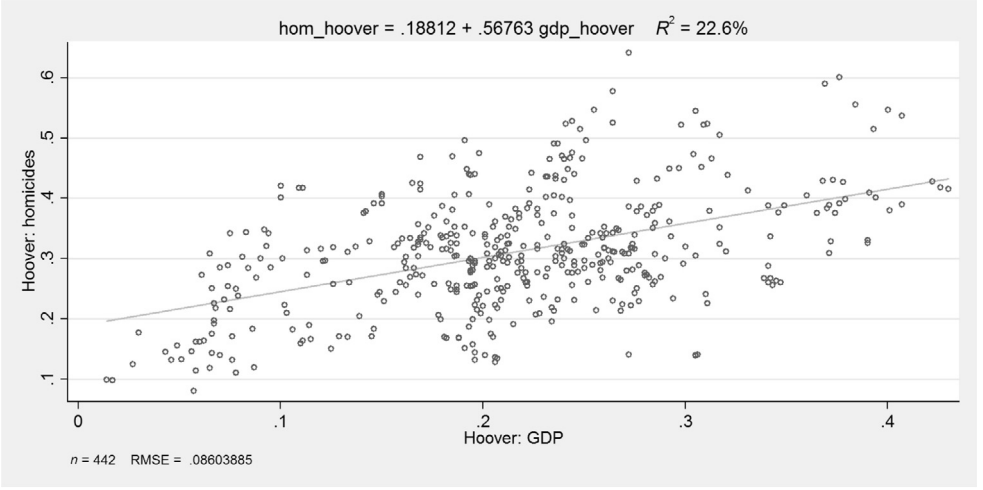
3.2. Interiorization of violence and economy

Central to our analysis is determining the degree to which violence is related to economic dynamism as presented spatially in Andrade and Diniz (2013). Given that we've demonstrated the interiorization of violence, we must also assess whether economic prosperity has also spread to the Brazilian interior. To this end, this section calculates a GDP Hoover to measure the interiorization of economic growth in Brazil across the same time period.

Fig. 4a and b shows a clear relationship between the distribution of homicides and the distribution of GDP, when considering municipalities in all the 26 Brazilian states. Fig. 4a captures the evolution of these distributions over time. At the beginning of the sample, in the 1990s, both homicides and GDP were unequally distributed and concentrated



(a) Calculated for all municipalities in Brazil



(b) Calculated for municipalities in 26 States

Fig. 4. Scatter between Hoover Index for GDP and Homicides. Source of data: SIM/SVS/MS and IBGE.

in urban areas. However, over time, both homicides and GDP became much more evenly distributed by 2011. Fig. 4b, highlights the overall relationship between violence and economic dynamism. The strong positive relationship between these two variables, suggests that during the same time period that homicides become more evenly distributed, GDP also became more evenly distributed. These figures corroborate the thesis of Andrade and Diniz (2013) that suggests violence tends to migrate toward areas of increased wealth.

3.3. Interiorization of violence and public safety

As previously addressed, the Brazilian media has taken note of the relationship between an insufficient police presence and rising levels of crime and violence. One hypothesis to explain this trend is that increased expenditures on public security in urban areas are causing violence to diffuse to the countryside. In other words, an increased police presence in big cities could be incentivizing criminals to target the relatively less protected countryside.

In order to test this hypothesis it is necessary to understand how state governments allocate their public security expenditures. Fig. 5 explains the relationship between per capita public security expenditures (constant values 2011),

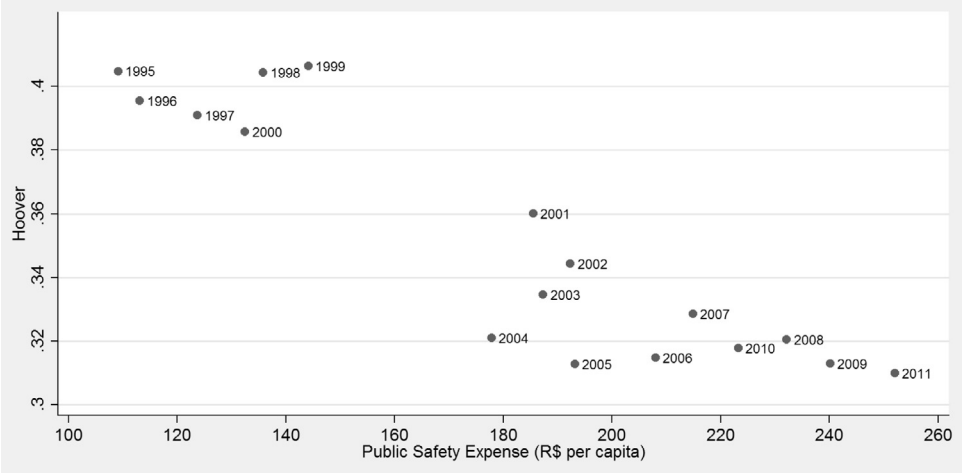


Fig. 5. Scatter between Public Security Expenditures, per capita, constant values 2011, and Hoover. Source of data: SIM/SVS/MS, STN and IBGE. Figure generated by authors.

and the homicide Hoover Index.[15] Fig. 5 shows that in the 1990s, when per capita spending was fairly low, Hoover values were relatively high, suggesting that homicidal violence was skewed toward more urban areas. Over time the trend shows that as state governments increased expenditures, levels of violence became more evenly distributed across states, raising the possibility that violence "leaked" from the cities to the countryside.

Closer analysis reveals that the government responded to alarmingly high levels of violence by increasing expenditures on law enforcement and public security. As observed in Fig. 5, real per capita expenditures for Brazil more than doubled from 1995 to 2011 from 109 to 252 reals per person. Adjusted for inflation, all states increased their public security budgets, some drastically so. Of note is the major increase in per capita expenditures between 2000 and 2001, which is visually represented by significant gap between these two years in Fig. 5. This marked increase in expenditures is attributed to the passage of the *Fundo Nacional de Segurança Pública* (FNSP, National Public Security Plan) that increased security expenditures in Brazil's most violent places.

These dramatic increases in security spending beg the following question: to what extent did these expenditures reshape the landscape of Brazilian violence? At first glance the relationship presented in Fig. 5, especially when coupled with daily news reports of increased countryside violence, seems to suggest that increases in public security expenditures, are *causing* this interiorization of violence.

However, if this graphic were constructed alongside other types of expenditures, such as education or health, a similar pattern of correlation would be found. This suggests that the correlation presented in Fig. 5, and propagated by the media, could be spurious. To illustrate this point, the same process was repeated with expenditures in education and health. As seen in Fig. 6 a similar correlation is found between these other types of government expenditures during the same period.

Analysis is hindered by the inability to break out the expenditures presented in Fig. 6 into urban and rural components. Databases are limited by the fact that states do not compile regionalized expenditure data. The inability to break out intra state expenditures makes it difficult to determine the relationship between the concentration of security expenditures in urban areas and the spread of violence. This limitation forces us to consider alternative ways to measure police force concentration. The proxy we develop to overcome this obstacle is discussed in the following section.

[15] To calculate public security expenditures, state expenditures in "public security" were collected from the national treasury: tesouro.fazenda.gov.br/estados_municipios. These values were adjusted to 2011 prices via the IPCA price index. Finally, these constant price level expenditures were divided by IBGE's population figures to arrive at per capita expenditures.

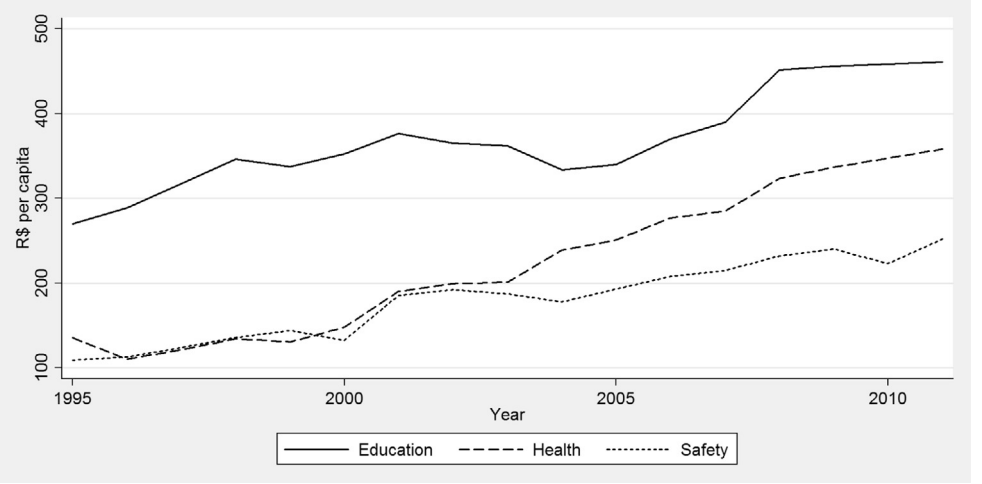


Fig. 6. Public Expenditures in Security, Health and Education, per capita, constant values 2011. Source of data: STN and IBGE. Figure generated by authors.

3.4. Proxy: the concentration of the police force in capital/metropolitan cities

Given the difficulties regarding data availability discussed in the previous section, we propose a proxy capable of measuring the concentration of a state's police force in its capital and metropolitan cities. The process to construct this proxy is explained in the following steps[16]:

- Compile census questionnaires from 2000 to 2010, as well as the PNAD household data from IBGE during the period 1995–2011.
- Of the people coded as "employed," we capture those coded with the occupation of CBO, throwing out missing observations.
- Select only the observations codes by the CBO as soldiers, military police, inspectors, detectives, and administrative clerks of the civil police.
- Among those selected, we apply the weight of each observation computed by IBGE according to their sampling scheme, and separate them into capital/metropolitan city or not.

First, to test the quality of the procedure, we aggregate our proxy summing up the weights of all the observations of municipalities of a given state and year, and then comparing it with the state-level data from ABSP (Annual Yearbook of Public Safety). Table 3 compares the total number of police in the state calculated by ABSP with our proxy for the percent of the police force living in the capitals or metropolitan areas in the years available in the directory. The high correlation between ABSP and the proxy suggests that the procedure is sound.

Next, we use this proxy to graphically compare the geographical distribution of the police force with the interiorization of violence. Below Fig. 7a shows a scatter plot between the the proxy for the percentage of policemen in capital/metropolitan cities at a national level alongside the homicide Hoover. In the national context, where 50–60 percent of the police force are resident in these urban areas, we note little evidence of correlation.

However, when broken out at the state level, as shown in Fig. 7b, a much stronger correlation is shown. This correlation suggests that in states where the police force is more heavily concentrated in urban areas, violence is also distributed more equally. This graphic seems to consistent with the vision espoused by the media, that higher expenditures in urban areas are correlated with lower Hoover values and an interiorization of violence. These correlations are analyzed more closely in the following sections.

[16] A similar procedure was adopted by Fajnzylber and Araujo Junior (2001).

Table 3
Estimates of the number of state police according to ABSP and the proposed proxy – in thousands.

State	2004		2006		2007		2009		2010		2011	
	ABSP	Proxy	ABSP	Proxy	ABSP	Proxy	ABSP	Proxy	ABSP	Proxy	ABSP	Proxy
Acre	3.6	2.2	2.7	2.4	2.8	2.0	3.0	2.4	3.0	2.8	3.9	2.6
Alagoas	9.7	4.5	9.4	8.7	10.2	12.1		8.5		8.1	9.5	8.3
Amapá	1.5	3.5	3.9	5.1	3.7	3.7	2.3	3.6	1.3	3.3	4.8	3.4
Amazonas	3.0	8.6	1.5	5.2	8.5	8.5	8.6	6.5	9.8	5.4	10.3	6.0
Bahia	28.1	26.8	33.7	26.9	32.8	27.0	43.6	23.4	33.8	23.9	37.6	23.7
Ceará	14.1	11.6	14.3	15.2	14.8	11.4		12.5		13.0	17.1	12.7
Espírito Santo	1.7	8.0	8.6	8.1	8.5	6.2	9.5	6.1	9.7	6.0	10.0	6.1
Goiás	15.2	17.2	16.0	12.4	16.1	14.6	17.3	12.2	14.4	10.8	15.9	11.4
Maranhão	7.9	8.8	8.0	3.3	9.2	7.9	7.2	8.7	7.6	7.1	9.8	7.9
Mato Grosso	8.4	9.6	8.5	7.8	9.9	5.5		6.0		5.4	9.6	5.7
Mato Grosso do Sul	6.1	6.2	6.9	4.9	6.6	3.2	3.4	4.7	3.0	5.1	7.6	4.9
Minas Gerais	46.1	47.8	49.6	43.1	58.0	42.4	55.8	45.8	55.4	39.5	55.6	42.8
Pará	2.5	15.2	2.6	19.0	15.8	13.6	17.8	15.4	21.3	13.9	2.9	14.7
Paraíba		7.2	10.6	8.5	11.3	3.8	6.8	7.4	9.4	7.4	11.1	7.4
Paraná	20.2	21.7	20.9	17.0	15.8	12.9	22.5	16.8	21.7	13.1	21.3	15.2
Pernambuco	21.8	16.3	21.4	20.7	24.1	18.1	20.2	18.1	19.1	18.9	25.6	18.5
Piauí		4.7	7.3	6.8	5.6	3.7	3.0	5.5	4.7	5.1	7.3	5.3
Rio de Janeiro	46.4	47.8		40.2	47.7	43.2		38.7		37.7	53.1	38.2
Rio Grande do Norte	8.9	7.0	9.3	10.4	9.3	8.3	8.8	8.8	9.1	7.1	11.0	8.0
Rio Grande do Sul	28.4	25.5	28.2	22.8	27.3	16.8	30.5	20.0	32.0	14.8	30.5	17.3
Rondônia	3.9	3.6	6.7	9.0	1.6	5.6		5.0		4.6	8.1	4.9
Roraima	2.6	1.1	2.0	1.8	1.5	2.1	1.5	1.6	1.3	1.4	1.5	1.5
Santa Catarina	11.8	9.8	14.3	12.7	15.0	8.5	15.7	14.7	13.5	9.4	14.6	12.2
São Paulo		85.9	124.0	89.1		74.1	157.9	78.4	109.9	64.7	119.5	71.8
Sergipe	4.9	7.0	6.8	8.6	6.8	9.0	6.8	5.2	6.5	4.3	6.6	4.7
Tocantins	4.9	4.1	4.9	2.4	5.6	0.7	7.1	4.0	5.8	3.2	5.5	3.6
Correlation	.955		.979		.986		.974		.985		.979	

3.5. Econometric model

We now propose an econometric model in order to compute conditional correlations and expand upon the information previously presented. The model we present is:

$$hhom_{jt} = \beta_0 + \beta_1 hgdp_{jt} + \beta_2 ppol_{jt} + \sum_{k=3}^{K} \beta_k X_{kjt} + C_j + T_t + \varepsilon_{jt}, \tag{1}$$

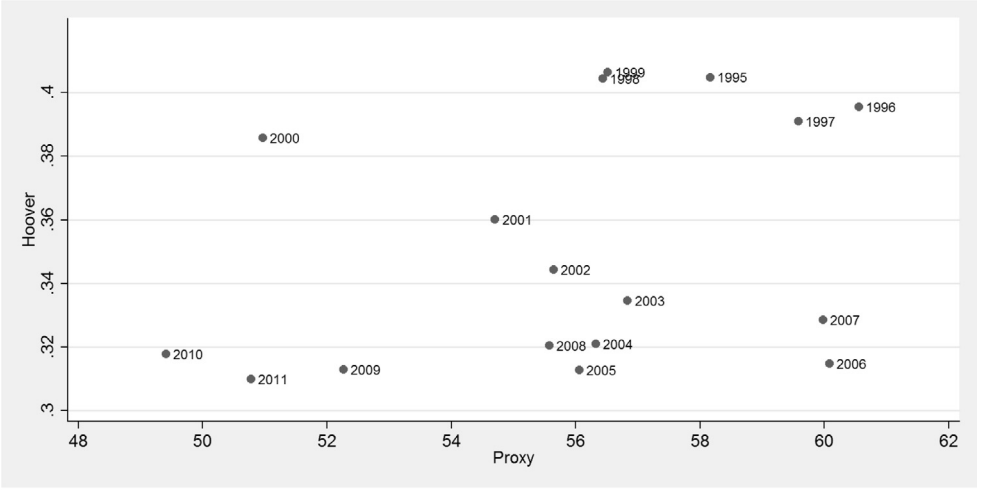
where $hhom_{jt}$ is the Hoover Index for homicides between the municipalities of state j in year t; $hgdp_{jt}$ is the Hoover Index for GDP; $ppol_{jt}$ is the % of Policemen in Capitals/Metros; X_{kjt} are covariates; C_i and T_t are fixed effects; and ε_{jt} and βs are the error term and the parameters, respectively.

As we are unable to observe *ppol* we adjust the model to incorporate the proxy. Therefore, $ppol = \alpha_0 + \alpha_1 ppol^* + u$, where $ppol^*$ is the proxy calculated using data from IBGE, the αs are parameters and u is an error term with a zero mean.

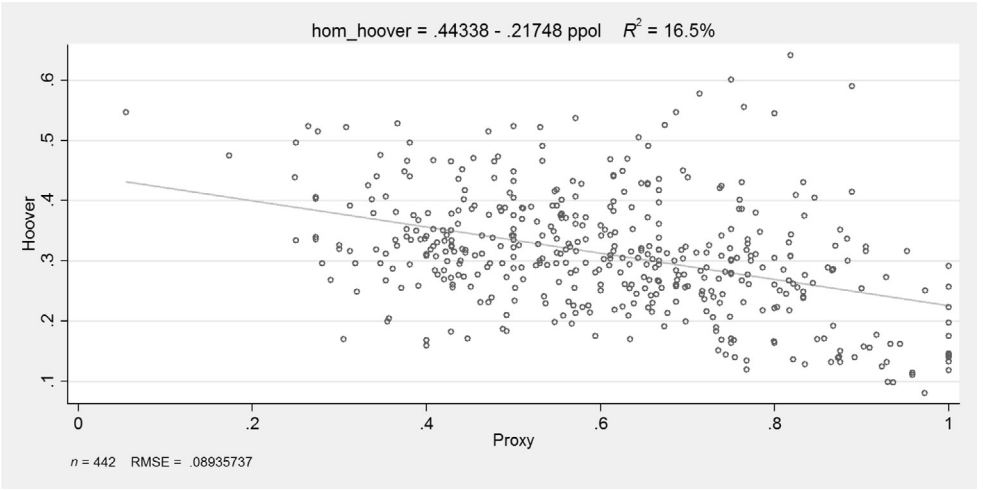
As Table 3 suggests, α_1 is likely positive and statistically significant. Considering this, we substitute $ppol = \alpha_0 + \alpha_1 ppol^* + u$ in Eq. (1) and encounter:

$$hhom_{jt} = (\beta_0 + \alpha_0\beta_2) + \beta_1 hgdp_{jt} + \beta_2\alpha_1 ppol^*_{jt} + \sum_{k=3}^{K} \beta_k X_{kjt} + C_j + T_t + \varepsilon^*_{jt}. \tag{2}$$

It is necessary to note that the $\text{plim}\hat{\beta}_1 = \beta_1 + \beta_2 \text{Cov}(hgdp,ppol)/\text{Var}(hgdp)$, which means the parameter estimating the relationship between the interiorization of violence and the interiorization of the economy is likely biased. Thus, we must account for the direction of this bias. In this sense, it appears reasonable that Cov(*hgdp*,*ppol*) is not negative,



(a) Calculated for all municipalities in Brazil



(b) Calculated for municipalities in 26 States

Fig. 7. Scatter between Proxy for % Police in Capitals/Metro and Hoover. Source of data: SIM/SVS/MS and IBGE.

otherwise it would imply that police presence in urban areas would decrease when economic activity is more heavily concentrated in these areas. Therefore, we assume the bias to be positive.

Additionally, as $\alpha_1 > 0$, the estimated sign for the product of $\beta_2\alpha_1$ is entirely determined by β_2. Therefore, if we have a correlation between the Hoover for homicides and the concentration of the police force, there would also be a correlation between the Hoover for homicides and the proposed **proxy** for police force concentration.

4. Estimated results and discussion

Table 4 presents the results of four specifications of our model. The first specification, presented in column (1), is the most basic and does not consider any X_{kjt}. There exists a significant correlation with the GDP Hoover, but not with the proxy for police concentration.

Specification (2) includes a variable with a linear tendency ($t = 1$ for 1995, 2 for 1996, etc.), in order to capture the continuous increase of the homicide rate in the interior over time, as presented in Fig. 1. Additionally, it includes a dummy for the years 2001 and beyond (*tdfsnp*) to capture the onset of the increased public security expenditures

Table 4
Estimation results.

Variables	(1)	(2)	(3)	(4)
hgdp	0.3672*	0.3672*	0.3768**	0.3755*
	(0.188)	(0.188)	(0.180)	(0.213)
ppol	0.0037	0.0037	0.0025	−0.0005
	(0.033)	(0.033)	(0.033)	(0.032)
t		0.0017	0.0018	−0.0011
		(0.004)	(0.004)	(0.006)
tdfsnp		0.0011	0.0011	0.0014
		(0.002)	(0.002)	(0.002)
tdarma		−0.0054***	-0.0054***	−0.0027
		(0.002)	(0.002)	(0.003)
homrate			0.0001	0.0004
			(0.001)	(0.001)
txpol				0.0694
				(2.805)
dens				0.0021*
				(0.001)
lngdp				−0.0789
				(0.150)
poor				0.1078
				(0.121)
phcrm				1.4322
				(1.253)
Fixed effects for time and states omitted				
Constant	0.2341***	0.2324***	0.2271***	−0.0010
	(0.067)	(0.070)	(0.068)	(0.401)
Observations	442	442	442	442
R-squared	0.322	0.342	0.344	0.385

Robust standard errors in parentheses.
*** $p<0.01$.
** $p<0.05$.
* $p<0.1$.

associated with the FNSP, as presented in Fig. 5. This specification also includes a dummy for 2004 and beyond in order to capture the effect of the Estatuto de Desarmamento (*tdarma*, Disarmament Statute), particularly in regards to declining homicide rates post 2004, mentioned in Fig. 1. This specification finds only the time dummy for the Estatuto de Desarmamento to be correlated with the interiorization of violence.

Specification (3) builds upon the previous by including the homicide rate of the states (*homrate*), trying to determine if more violent states are prone to greater interiorization of violence. The results suggest no evidence that violent states experienced interioriaztion to a greater extent.

The final specification in column (4) is the most robust and includes: the number of police per 100 thousand inhabitants (*txpol*), testing if states with larger police presences have a more equal distribution of violence; population density (*dens*), testing if more densely populated states have greater interiorization; the log of GDP (*gdp*), testing if states with larger GDP have a more equal distribution of violence; the percent of families with per capita family income less than half minimum wage (*poor*), testing if states with most unequal income distribution have greater interiorization of violence; and, the percent of the population in capital and metropolitan regions that is young and male (*phcrm*), returning to the fact that "Nearly two in five of all registered deaths for men aged 15–24 are the result of homicides." There is little evidence that any of these covariates are strongly correlated with the interiorization of violence.

Given the wide array of variables related to violence, we realize that we could include more covariates. However, the main objective of this research is not to find *all* possible explanations for the interiorization of violence. Rather, this research's objectives are more modest: to empirically test the hypothesis of Andrade and Diniz (2013) using the locational homicide Hoover index as a measure for violence distribution, and to test the idea transmitted through the media that violence has spread to the countryside due to higher police concentrations in urban areas. To that end, the

results of our empirical analysis are consistent with Andrade and Diniz (2013)'s findings that the violence is spreading to more rural areas with new-found economic dynamism. However, we find little evidence of a relationship between high concentrations of police in capital/metropolitan cities and the spread of violence to the countryside. Counter to what is reported in the media, it seems that other factors are at play to incentivize criminals to pursue targets in the countryside.

5. Conclusion

This research proposes the use of locational Hoover indices as a superior method to capture the phenomenon of the interiorization of violence put forward by Waiselfisz (2011). The locational Hoover, which captures the relative imbalance between any two entities into a single variable, has advantages of straightforward numerical interpretation, ease of calculation, and unlike the Gini index, is invariant to ordering in multivariate data sets. These are some of the desirable characteristics that make the Hoover Index well-suited to analyze the dispersion of violence over time.

Additionally, we developed a proxy to measure the geographic concentration of the police force within states, to overcome database limitations. This proxy was crucial to adequately investigate the media's implied assertion that a heavier police presence in urban areas caused a dispersion of violence to the less protected countryside. Furthermore, the procedures used to develop this proxy could be repeated by future researchers to determine not only the concentration of the police force, but host of other occupations whose intra state distributions are unknown. Even with the limitations of current databases, researchers now have a reliable way to create a proxy for key variables in order to continue analyzing important social trends.

Furthermore, the press implied a causal relationship between increased violence in more rural places and a lack of policing in these areas relative to big cities. To investigate this possibility, this research utilizes the proxy developed to explore the link between the dispersion of violence to the countryside and a heavier concentration of the police forces in urban areas. While it is undisputed that less populated areas with few security resources are left more vulnerable to crime and violence, this research finds no evidence supporting a causal link between high police concentrations in big cities and the dispersion of violent crime. Violence certainly is spreading to the countryside, but it seems that other factors are at play that are incentivizing criminals to pursue targets in the countryside.

Increased economic prosperity seems to be one of these factors that seems to incentivize the migration of violence. As proposed by Andrade and Diniz (2013), violence diffused from urban centers to areas of increased economic dynamism in less populated areas. Their research used spatial analysis to show that areas of greater economic prosperity, specifically smaller Brazilian cities, was central to attracting violence. Our research validated their assertion via empirical methods to arrive at the same conclusion: violence is following the money.

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